Discounted Cash Flow Model Efficient Market Hypothesis

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Price vs Value of stocks

- Today it has become so easy and fast to buy stocks that the sense of partnership in a business, intrinsic in being a shareholder, is almost lost among investors and replaced by the thrill of participating of the sudden gains or losses registered in the quotes table, and nothing more

- The company behind the stock is not as much considered as the figures quoted at the market, when it comes to buying, or selling, by many investors

- Thus, the price of a stock often does not reflect the worth of its business and is completely determined by what people are willing to pay for it:

The price of a stock is determined by the forces of supply and demand from investors

The Discounted Cash Flow model

- For an investor the value of a stock depends on the possible future capital gains that can be made from investing in it
- The future gains come from the expected dividend per share and the expected price appreciation per share
- Then to have an estimate of the *present value* S_0 of a share of a stock, say 1 year ahead, taking into account these sources of capital gain, the most common and simple model is to estimate the expected future payoff (future price plus dividend), and disregarding transaction costs and considering a constant discount rate r per year, discount this cash flow back to present to obtain:

$$S_0 = \frac{D_1 + S_1}{1 + r}$$

where D_1 and S_1 are the expected dividend and expected price per share after a year

The Discounted Cash Flow model

- The next year price per share can be forecasted also by applying the same discount formula to S_1, obtaining:

$$S_0 = \frac{D_1}{1+r} + \frac{D_2}{(1+r)^2} + \frac{S_2}{(1+r)^2}$$

- which determines the present value of the stock in terms of expected yearly dividends, for the next 2 years, and expected price at the end of second year, everything discounted by a constant rate

- Repeating for an arbitrary number T of years one gets the general formula:

$$S_0 = \sum_{t=1}^{T} \frac{D_t}{(1+r)^t} + \frac{S_T}{(1+r)^T}$$

- where D_t is the expected dividend for year $t = 1, \ldots, T$, and S_T is the expected price at the end of the investment horizon

The Discounted Cash Flow model

- one should think that prices could not grow forever while the discount rate keeps accumulating; hence, it is reasonable to assume that the expected discounted future price approaches zero as the investment horizon T goes to infinity

$$S_0 = \sum_{t=1}^{T} \frac{D_t}{(1+r)^t} + \frac{S_T}{(1+r)^T}$$

- This is known as the *discounted cash flow* (DCF) formula for the present value of a stock, which represents the actual price as a perpetual stream of expected cash dividends

$$S_0 = \sum_{t=1}^{T} \frac{D_t}{(1+r)^t}$$

DCF and forecasts

- To make estimations with DCF (or with the partial sum) we should first make precise the nature of the discount rate *r*

- In principle, it could be taken as the risk-free interest rate of a high grade bond, but that would be an underestimation and does not reflects the investors acceptance of risk

- Consider instead resolving *r* from $S_0 = \frac{D_1+S_1}{1+r}$, then $r = \frac{D_1+S_1}{S_0} - 1$

- This says that *r* is the expected return for the stock, or it could also be the expected return of any other asset with similar risk as the one we are analyzing. This way to compute *r* is known as *market capitalization rate* or *cost of equity capital*, and it is a more accurate interpretation for the discount rate *r*

DCF and forecasts

- Thus, with an estimation of future gains at hand, knowing the cost of equity capital, we can calculate the present value of the stock; or knowing the present (intrinsic) value of the stock we can calculate its expected return

- The **modeling of expected returns** and **forecasting of price** are not simple matters, and are subjects of a large corpora of research papers

Arbitrage

- A fundamental economic assumption underlying many mathematical models of price is that it is not possible to make a profit without a risk of losing money… that is not possible to get something from nothing

- Milton Freedman:

“*There is no such a thing as a free lunch*”

- This assumption is formally summarized as the *principle of no arbitrage:*

Principle of No Arbitrage: there are no arbitrage opportunities

Arbitrage

- The "no arbitrage principle" is usually accompanied with other mild assumptions simply named *extended no arbitrage*

Definition *"Extended no arbitrage"*

The *extended no arbitrage* is the following list of assumptions about the market of securities:

  - Arbitrage is not possible
  - There are no transaction costs, no taxes, and no restrictions on short selling
  - It is possible to borrow and lend at equal risk-free interest rates
  - All securities are perfectly divisible

Consequences of extended no arbitrage

- **Proposition 1.1** *Assuming extended no arbitrage, two portfolios with equal value at time T must have equal value at all time $t \leq T$*

- **Proposition 1.2** *Assuming extended no arbitrage, if A and B are two portfolios with $v(A , T) \geq v(B, T)$ then, for all time $t \leq T$, $v(A , t) \geq v(B, T)$*

- Proposition 1.1 – in particular – offers a technique named “replicating portfolio” used to price a derivative, such as option and forward contracts

Risk-neutral valuation

- A very simple way to value an option can be derived from the assumption that investors are indifferent about risk: **risk-neutrality** is a strong hypothesis but make for doing pretty valuation

- In a risk-neutral world all securities should behave much like a bond. Therefore, on the one hand, the rate of benefit that investors can expect from a stock should be equal to the risk-free rate, since they don't care about risk

- On the other hand, the present value of a derivative can be obtained by calculating its expected future value, and discounting it back to present at the risk-free rate (Lesson 1, slide 25):

$$S_T + D_T - C(S_0)e^{rT}$$

An example

We wanted to write a call option on stock XYZ, with 6 months to maturity and exercise price K = 115€. We assume that the current price of the stock is equal to K. The risk-free interest rate for the life of the call is r = 0.015, and it is assumed that by the end of the period the price of the stock may go up 30% or down 20%. With this information, and assuming investors are neutral to risk, we can compute the probability p of the stock going up, since the expected rate of benefit can be estimated as the sum of all the outcomes' probabilities weighted by their expectations, and all this is assumed equal to r.

We have, Expected rate of benefit = $(p \times 0.3) + (1 - p) \times (-0.2) = 0.015$ → This gives $p = 0.43$

On the other hand, the payoff of the option is C_u = 34.5 (if stock goes up), or C_d = 0 (if stock goes down) Then the expected future value of the option (EC) is the sum of these possible values weighed by their probabilities of occurring

$EC = (p \times C_u) + (1 - p) \times C_d = 0.43 \times 34.5 + 0.57 \times 0 = 14.84$

The present value C of the call is $C = EC \ / \ (1+r) = 14.84 \ / \ 1.015 = 14.62$€

The Efficient Market Hypothesis (EMH)

- A more general paradigm for market equilibrium arises from the assumption that markets are "informationally efficient":

The information available at the time of making an investment is already reflected in the prices of the securities, and in consequence market participants can not take advantage of this information to make a profit over the average market returns

Testing EMH

- There is a large number of research papers devoted to testing the EMH

- The general methodology underlying consists of a two part process:
  - first, the design of a trading strategy based on an specific set of information
  - second, to measure the excess return over average returns obtained by the trading strategy.

- For the first part one must specify the information set, and in this regard the general accepted forms of efficiency are:
  - **Weak**: only the price history of the securities constitutes the available information
  - **Semi-strong**: all *public* information known up to the present time is available
  - **Strong**: all *public and private* information (i.e., all possible information) known up to the present time is available

Testing EMH

- Trading strategies based on Technical Analysis are tests for the weak EMH, since their basic paradigm is to rely solely on the past history of the price, while those strategies based on Fundamental Analysis are tests for the semi-strong EMH

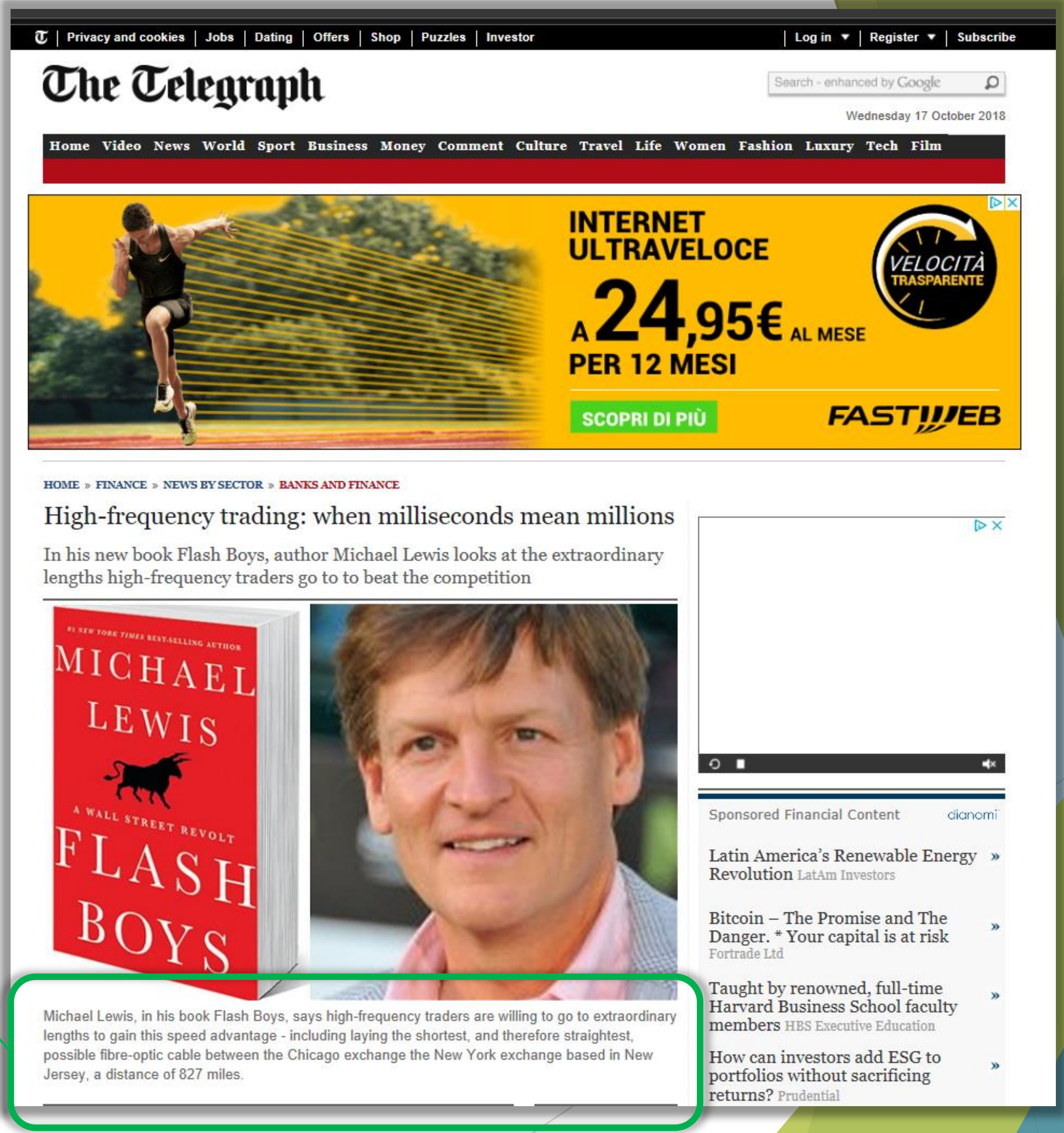
Strong EMH

- As for the strong form of the EMH, there are several arguments for its impossibility in practice
- For example, Grossman and Stiglitz (1980) developed a *noisy rational expectations* model that includes a variable that reflects the cost for obtaining information, besides the observable price
- Then they showed that, in a competitive market, informed traders (those who pay the cost for the information) do have an advantage over uninformed traders (those who only observe prices), since prices cannot reflect all possible information
- Thus, while their model supports the weak EMH, it does not supports the strong form of the EMH

EMH and Computational Complexity

- A recently developed conception of market efficiency in terms of computational complexity might better explain the experienced inefficiency of markets by some financial traders, who have made profits with their own strategies and models
- From a computational complexity point of view, a market is defined to be efficient with respect to computational resources R (e.g. time or memory), if no strategy using resources R can generate a substantial profit
- This definition allows for markets to be efficient for some investors but not for others
- Those who have at their disposal powerful computational facilities (let these be machines or human expert programmers) should have an advantage over those who haven’t
- Note that this definition is in the same spirit of noise rational expectation models mentioned above, but the relativization of efficiency is not to a monetary cost but rather to a computational cost

Michael Lewis, in his book Flash Boys, says high-frequency traders are willing to go to extraordinary lengths to gain this speed advantage - including laying the shortest, and therefore straightest, possible fibre-optic cable between the Chicago exchange the New York exchange based in New Jersey, a distance of 827 miles.



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High-frequency trading: when milliseconds mean millions

In his new book Flash Boys, author Michael Lewis looks at the extraordinary lengths high-frequency traders go to to beat the competition

Michael Lewis, in his book Flash Boys, says high-frequency traders are willing to go to extraordinary lengths to gain this speed advantage - including laying the shortest, and therefore straightest, possible fibre-optic cable between the Chicago exchange the New York exchange based in New Jersey, a distance of 827 miles.